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Original Article

Comparison of Performance of Internal Combustion Engine Fuelled with Diesel and Biodiesel (used Vegetable Oil) Blends

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Abstract *- Due to the rising mechanical requirements, the cost of customary powers is becoming more expensive. Rough oil use contributes to increasing environmental pollution; hence it is necessary to look into alternative fuel sources with little to no environmental impact before using them for vehicles and other purposes. The combustion characteristics and thermal performance of the diesel fuel-burned internal combustion engine (DICE) were explored in this paper after employing biodiesel (containing a blend of used vegetable oil and diesel) in steady-state operation using vegetable oil utilised as biodiesel. They were mixed with diesel fuel in varying used vegetable oil concentrations of 5 %, 10 %, 15%, and 20 %, respectively. The DICE utilised in this study was a single-cylinder, four-stroke, water-cooled diesel engine. The analysis revealed that biodiesel blends (UBF20) showed 49% higher indicated power than diesel at 1498 rpm. Generated torque of biodiesel blends (UBF5, UBF10, UBF15, and UBF20) was nearly similar to that of diesel at different loads and speeds.*

Keywords *- Internal combustion engine, Biodiesel, and Engine performance.*

1. Introduction

The limited fossil fuel sources associated with ever-increasing consumption rates suggested that internal combustion engines (ICE) will last for only a short time [1-3]. Also, increasing exhaust gas emissions and crude oil prices are other factors generating attention while using diesel as a fuel in an ICE. Major pollutant gas such as carbon monoxide, unburned hydrocarbons, and smoke opacity affect human health and environmental condition [4]. Thus, finding alternate and sustainable fuel to replace diesel fuel is of immense significance. In this regard, biodiesel may act as an alternative fuel as it is extracted from plant seeds or biomass through the transesterification process. Biodiesel is a petroleum-free renewable fuel that can be blended with diesel and used in the engine with or without engine modification. In view of environmental concerns, socioeconomic and foreign exchange use of biofuel is increasing rapidly in the automotive industry during the 21st century [5,6]. Various biodiesels (vegetable oils, edible and nonedible) have been utilised to generate power in ICE as an alternative energy source.

2. Review of literature

Adam et al. [7] analysed IC engine combustion, performance, and exhaust emissions characteristics fuelled with upgraded waste source fuel. Further, it has been suggested that upgraded waste cooking oil showed 14% higher power and 13.8% higher torque than regular diesel. Experimental investigations on CI engines' performance and emission characteristics with neem oil biodiesel and its blends instead of diesel fuel have been carried out by Kannan et al. [8]. They concluded that the thermal brake efficiency (BTE) of CI engines using neem oil biodiesel blends B20 and diesel give nearly similar results. Anandhan et al. [9] tested Jojoba oil biodiesel and analysed the performance and emission characteristics of diesel engines. They observed that B20 had the highest BTE and lowest smoke, CO, HC emissions and NOx in biodiesel diesel blends while increasing the load. Further, Suresh et al. [31] investigated a diesel engine's performance and emission characteristics with cardanol-based hybrid bio-diesel blends and reported that the thermal brake efficiency of hybrid biodiesel was nearly similar to that of diesel at full load.

Parashuram et al.[11] used biodiesel blends extracted from jatropha oilseeds in a two-cylinder CRDI CI engine and showed improved BTE. Ekrem [12] used the blended rapeseed oil of 20%, 50% and 70% in diesel in a DI diesel engine and studied the combustion, performance and emissions. There was an increment in BSFC with the increment in the proportion of blends. Rahman et al. [13] used jatropha curcas biodiesel (JB10) and moringa oleifera biodiesel (MB10) fuel blends of 10% each in a compression ignition engine. They reported that JB10 and MB10 yielded lower BP and higher BSFC than diesel. Sahoo et al. [14] fuelled polanga seed oil with high acid value blended with high-speed diesel (HSD) in varying quanta of 20%-100% in the diesel engine. The optimum engine operating conditions were found to be best for reduced BSFC and increased BTE (by 0.1%) at full load for pure biodiesel. Mofijur et al. [15] used jatropha biodiesel mixed with diesel in the ratio of 10 and 20 % in a compression ignition engine. The evaluation showed that BP reduced by 4.67% and 8.865% for B10 and B20, respectively, compared to pure diesel (B0). The BSFC increased with an increased proportion of biodiesel. The average values of BSFC for B0, B10, and B20 were found to be 273.5 g/kWh, 278.46 g/kWh, and 281.9 g/kWh, respectively. Similar results were obtained by [16-21]. Shanmughasundaram et al. [32] fueled corn oil biodiesel in diesel engines and reported that B20 showed an increase in BTE by 25.33% when the air was preheated by 35 °C to 50 °C. BSFC of B20 (0.19 kg/kW-hr) was found to be lesser than pure diesel (0.24 kg/kW-hr) for the same brake power output (5.54 kW). Vatika et al. [23] used canola oil methyl ester B5, B10, B15, B20 and B25 in diesel engines and observed that the maximum BTE was found to be 31.06% for B15, which is higher than 29.87% of diesel. Dawody et al. [24] observed that the smoke opacity for biodiesel was reduced by 48.23%, and BSFC increased by 14.65% more than diesel. Soudagar et al. [25] used Ricinus Communis biodiesel-diesel blended fuel in a CRDI engine and reported an increment in BTE by 20.83% and decrement in BSFC by 20.07%. Wouter et al. [26,27] analysed jatropha biodiesel's sustainability by fuelling it in a diesel engine. The study showed that jatropha biodiesel proved to offer resistance to drought and is multipurpose. Monirul et al. [28] assessed the combustion, performance and exhaust emission concentrations of diesel engines employed with biodiesels derived from the palm (PB), jatropha (JB) and Calophyl- lumInophyllum (CIB). It was observed that BSFC increased by 7.96– 10.15% for 10% and 20% of PB, JB and CIB blends; similar observations were reported by [29,30].

In the present investigation, an attempt has been made to evaluate the engine performances (power, torque, fuel consumption) and percent emissions of diesel engines using various bio-diesels blends (UBF5, UBF10, UBF15, and UBF20) at different loads and speeds. The comparison of performance (in terms of different parameters) in different blends has also been made with diesel performance.

3. Materials and Methods

The present experiments have been conducted on diesel fuel-burned internal combustion engines (DICE). The diesel engine technical details have been described in Table 1. The instruments utilised as a part of this testing is tuned periodically, considering the unsteadiness of all parameters. The research engine test arrangement is shown in Fig. 1. Investigations on single cylinder four stroke diesel engines based on used vegetable oil as biodiesel were performed to analyse the engine performance parameters. In the experiment, an engine was run on diesel and used vegetable oil blends (UBF5, UBF10, UBF15, and UBF20) at different loads. UBF5 (5% used vegetable oil and 95% diesel), BF10(10% used vegetable oil and 90% diesel), UBF15 (15% used vegetable oil and 85% diesel) and UBF20 (20% used vegetable oil and 80% diesel.

4. Results and Discussion

The engine power at different engine loads and speeds after using different blends is shown in Figure 2. Noticeable is the maximum power for UBF20 at different engine loads (40%, 60%, 80% and 100%) and speed (1498, 1477, 1461 and 1445 rpm)

Table 1. Specifications of the diesel engine arrangement

Power/speed	3.50 kW /1500 rpm
Cylinder bore	87.50 mm
Stroke length	110.00 mm
Connecting Rod length	234.00 mm
Number of Cylinders	1
Swept volume	661.45 cc
Compression Ratio	12:1to 22:1
Orifice Diameter	20.00 mm
Orifice Coeff. Of Discharge	0.60
Dynamometer Arm Length	185 mm
Fuel Pipe diameter	12.40 mm

Fig. 1 Photographic view of experimental engine setup

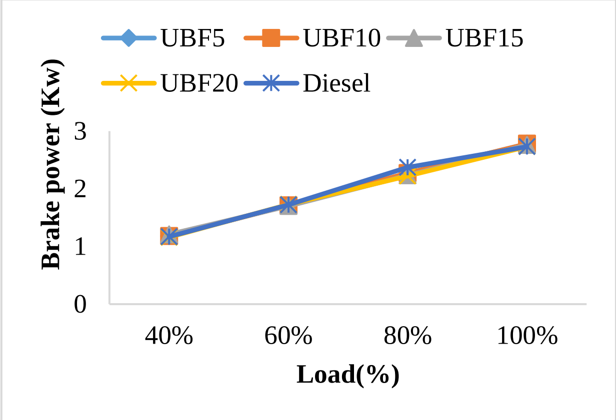

Fig. 2 Variation of indicated power at different engine loads and speeds

Figure 3 shows the brake power at different engine loads and speeds. It is observed that brake power is approximately similar at different engine loads (40%, 60%, 80% and 100%) and speeds (1498,1477,1461 and 1445 rpm). The trends of the graph follow a nearly similar curve with regular diesel.

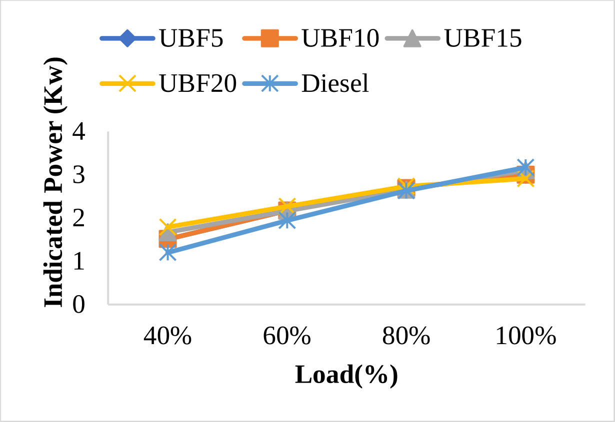

Fig. 3 Variation of brake power at different engine loads and speed

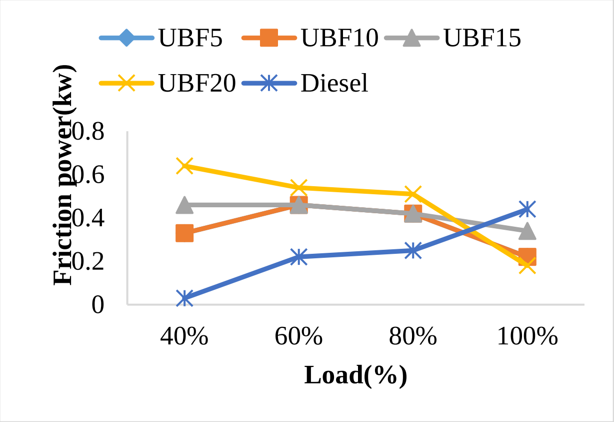

Fig. 4 Variation in the friction power at varying engine load and speed

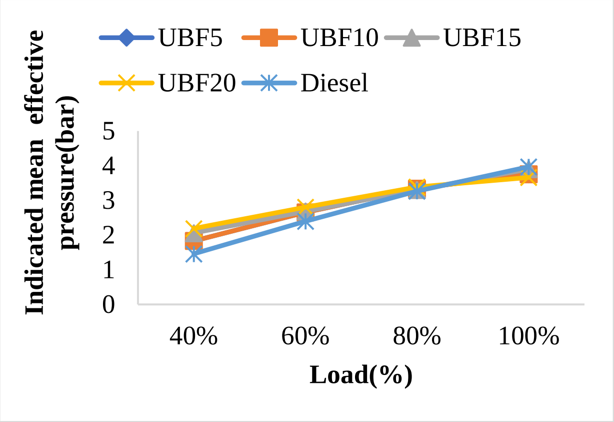

Fig. 5 Variation of indicated mean effective pressure at different engine loads and speeds

The friction power at different engine loads and speeds has been shown in Figure 4. It is observed that friction power for UBF20 is slightly higher than other blends at different engine loads (40%,60%, 80% and 100%) and speeds (1498, 1477, 1461 and 1445 rpm).

The indicated mean effective pressure at different engine loads and speeds have been plotted in Figure 5.

The brake means effective pressure at different engine loads and speeds in the different blends, and the diesel, as fuel, almost follows a similar trend (Figure 6).

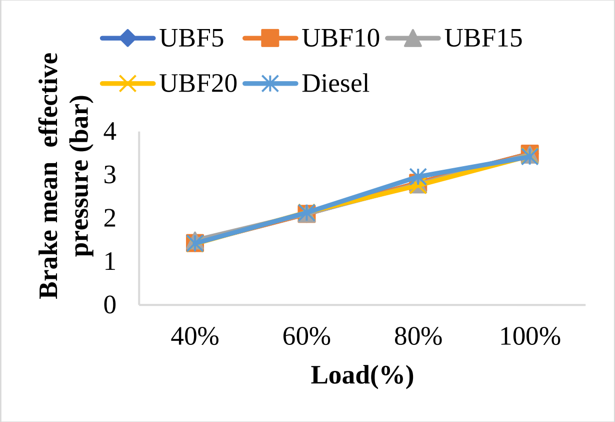

Fig. 6 Variation of brake mean effective pressure at different engine load and speed

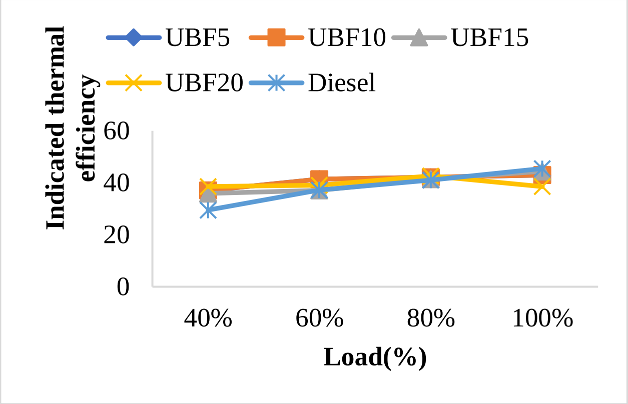

Fig. 7 Variation of indicated thermal efficiency at different engine loads and speeds.

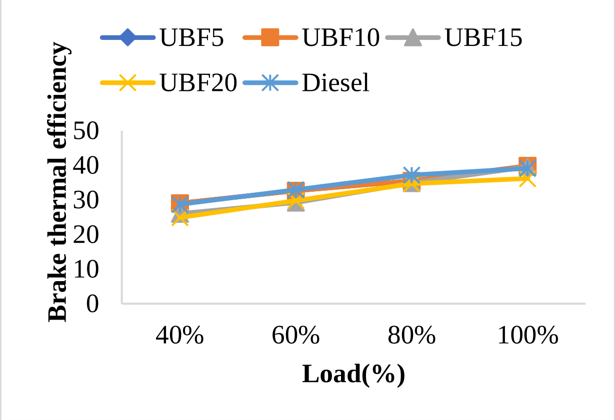

Fig. 8 Variation of brake thermal efficiency at different engine loads and speed

The indicated thermal efficiency at different engine loads and speeds is given in Figure 7. The average indicated thermal efficiency for diesel and other blends is almost similar.

The thermal brake efficiency at different engine loads and speeds is shown in Figure 8. The thermal brake efficiency for diesel is slightly higher than other blends at different engine loads (40%,60%, 80% and 100%) and speeds (1498, 1477, 1461 and 1445 rpm)

Figure 9 shows the specific fuel consumption at different engine loads and speeds. It is observed that consumption of UBF5, UBF10, UBF15, and UBF20 is slightly higher than diesel at different engine loads (40%,60%,80, and 100%) and speeds (1498,1477,1461 and 1445 rpm).

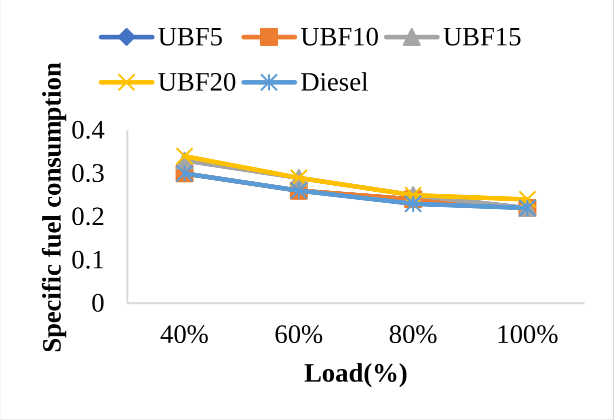

Fig. 9 Variation of specific fuel consumption (SFC)at different engine loads and speed

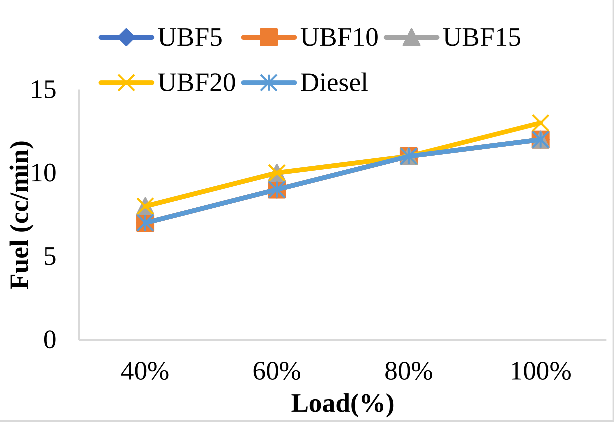

Fig. 10 Variation of fuel (cc/min) at different engine loads and speed

The fuel consumption at different engine loads and speeds is given in Figure 10. It has observed that consumption of UBF5, UBF10, UBF15, and UBF20 is slightly higher compared to diesel at different engine loads (40%,60%, 80% and 100%) and speeds (1498, 1477, 1461 and 1445 rpm).

Figure 11 shows the torque at various engine loads and speeds. The generated torque for UBF5, UBF10, UBF15, UBF20 and diesel is similar at different engine loads (40%,60%,80% and 100%) and speeds (1498, 1477, 1461 and 1445 rpm).

The mechanical efficiency at different engine loads and speeds is shown in Figure 12. It is observed that mechanical efficiency for diesel is slightly higher compared to other blends at different engine loads (40%,60%, 80% and 100%) and speeds (1498, 1477, 1461 and 1445 rpm).

The emission of percent carbon at different engine loads and speeds is given in Figure 13. Noticeably, the carbon emission was higher for diesel than other blends at different engine loads (40%,60%, 80% and 100%) and speeds (1498, 1477, 1461 and 1445 rpm).

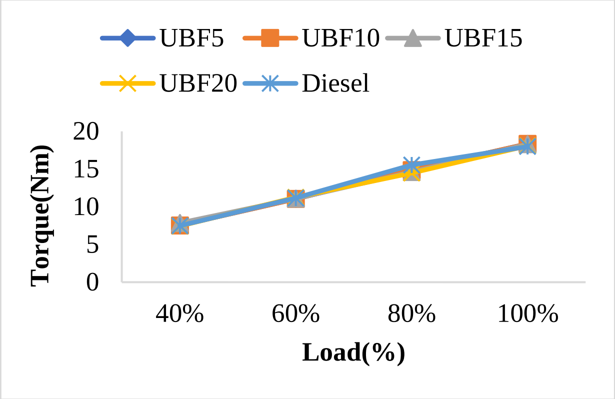

Fig. 11 Variation of torque at different engine loads and speed

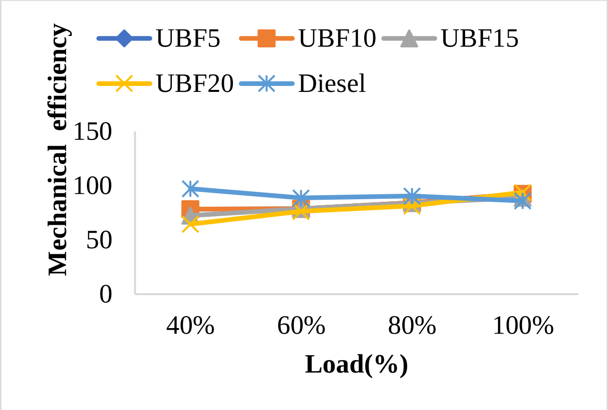

Fig. 12 Variation of mechanical efficiency at different engine loads and speed

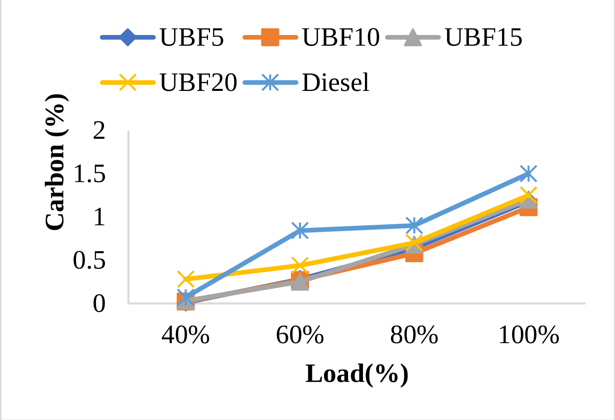

Fig. 13 Variation of carbon percentage at different engine loads and speed

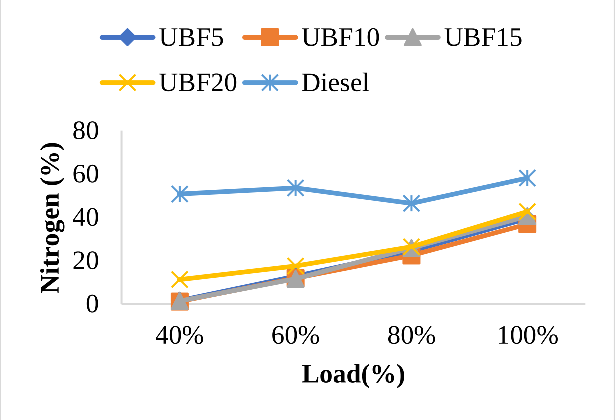

Fig. 14 Variation of nitrogen percentage at different engine loads and speed

Similarly, the nitrogen emission (percentage) at different engine loads and speeds was lower for UBF5, UBF10, UBF15, and UBF20 compared to diesel as fuel (Figure 14).

5. Conclusion

The present study investigating the effect of the use of vegetable oil as biodiesel blends on the performance (in terms of various parameters) of diesel engines revealed the following:

- The indicated brake, friction power and break mean effective pressure was similar for diesel and other blends used in the experiments.
- The specific fuel consumption values were higher for the diesel compared to various biodiesel blends.
- The torque generated in the engine for diesel and biodiesel blends is almost the same.
- Mechanical efficiency for diesel is higher than other blends because of biodiesel's low calorific value.
- The exhaust of carbon (%) for diesel was higher than other blends (UBF5, UBF10, UBF15, and UBF20) at different engine loads and speeds.
- The emission of nitrogen (%) was higher for the diesel compared to other blends (UBF5, UBF10, UBF15, and UBF20) used in the experiments.

Given the abovementioned parameters, it can be suggested that using biodiesel blends may significantly contribute to reducing the demand for diesel. Such utilisation of biodiesel blends will also help mitigate environmental issues related to excessive fossil fuel use.

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